Polarization measurements of 100 GeV proton beams at RHIC by elastic proton-proton and proton-carbon scattering

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The two types of polarimeter have been developed to measure polarizations of proton beams at relativistic heavy-ion collider (RHIC). A pC polarimeter[1)] provides a relative polarization by measuring asymmetries in left-right yields (N_{left}, N_{right}) of recoil carbon events through elastic proton-carbon reaction. The absolute beam polarization $P_{\rm beam}$ is given by normalizing the measured asymmetries by the analyzing power for the elastic pC process $A_{\rm N}^{pC}(t)$

$$P_{\rm beam} = \frac{1}{A_{\rm N}^{pC}(t)} \frac{N_{left} - N_{right}}{N_{left} + N_{right}}, \qquad (1)$$

where t is 4-momentum transfer. The silicon strip detectors were implemented around 90° to select the elastic process to be very peripheral ($0.001 < |t| < 0.035$ (GeV/c)^2). This is because the t dependent analyzing power is expected to be maximum due to the interference between the electromagnetic and the nuclear strong force amplitudes. This kinematic region is known as Coulomb Nuclear Interference (CNI) region. However, because of the poorly known hadronic spin-flip mechanism at high energy as 100 GeV[?)], the A_N^{pC} is not exactly predictable. Thus the A_N^{pC} is somewhat determined experimentally from the measured t dependence of the asymmetries and its absolute calibration is obtained from the polarized hydrogen gas jet polarimeter[4)] data which was operated in parallel with the pC polarimeter. Since the target polarization $P_{\rm target}$ is accurately monitored by a Breit-Rabi polarimeter, the jet polarimeter can translate it to the absolute beam polarization using a following ratio:

$$\frac{P_{\rm target}}{P_{\rm beam}} = \frac{\epsilon_{\rm target}}{\epsilon_{\rm beam}} \qquad (2)$$

where $\epsilon_{\rm target}, \epsilon_{\rm beam}$ are left-right asymmetries $N_{left} - N_{right}/N_{left} + N_{right}$ observed when either the target or the beam is polarized, respectively. The A_N^{pC} used for Run5 online polarization measurements was calibrated by the preliminary analysis result of the Run4 hydrogen polarimeter data with 8.5% uncertainty. The uncertainty is currently dominated by the statistics and it will be improved cumulatively as increasing data from Run5 and future runs. During Run5, the measurements on both blue and yellow beams simultaneously/sequentially were attempted for the first time and consequently the accumulated statistics amounted about factor of 4 of the Run4 data. On the other hand, the signal to noise ratio got worse by factor of two for an unclear reason. The cause of this is under investigation.

As a result of Run3 and Run4 analysis, the uncertainty of each pC polarization measurement is 12 to 19 percent. The RHIC-spin program requires to measure the proton beam polarization within 5 percent accuracy. In order to achieve this goal, continuous efforts to improve the measurements have been spent for Run5. One of the major modifications is in the strip detector of the pC polarimeter, a beam induced pickup noise was significantly suppressed by improving grounding design of silicon strips. The stability of the baseline of the signal is then expected to provide the more reliable calibration scale in ADC to energy conversion which is one of the largest error sources of Run3 and Run4 data.

References

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